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Evaluation of the Communications Earplug in the H-53 and CH-46 Helicopter Environments

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An evaluation of the communications earplug (CEP), requested by NAVAIR PM-202, was conducted at HMX-1 Operational Test and Evaluation Department, Quantico, Virginia. The evaluation was completed by 15 volunteer aviator/crewmembers flying CH-46 and CH-53 helicopters over a 4-month period. The CEP is a miniature earphone attachable to a replaceable foam earplug. The CEP provides excellent hearing protection and speech communications for the wearer. Questionnaires were used to capture the users' subjective comparisons of the CEP and the helmet system normally worn. Results showed significant improvements in noise reduction, speech clarity and quality. Donning and doffing using the CEP was assessed at a slightly lower level than the helmet normally used, while comfort was ranked as equal. Overall value was rated significantly better than the normally used helmet.

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Background

Noise levels inside military helicopters generally exceed noise exposure limits established by DOD Instruction 6055.12, "Hearing conservation" (1991). Noise levels in helicopters with higher load capacities such as the CH-47, CH-46, and H-53 are extremely high and sometimes exceed the helmet's capability to provide adequate hearing protection for crewmembers. Noise compromises communication because of inadequate speech signal to noise ratio at the ear (Mozo, Murphy, and Ribera, 1995; Ribera et al., 1996; Mozo and Murphy, 1997; and Staton, Mozo, and Murphy, 1997). Use of combination protection, earplug in addition to the helmet, does provide the necessary hearing protection, but further compounds the problems associated with communications capability. While active noise reduction (ANR) provides exceptional low frequency hearing protection, it does little or nothing to improve protection for frequencies above 800 hertz. A U.S. Army Aeromedical Research Laboratory (USAARL) report (Mozo and Murphy, 1997) shows ANR does improve speech intelligibility when worn alone, but both hearing protection and speech intelligibility are degraded when worn with ancillary equipment such as spectacles and chemical/biological (CB) mask. Aircraft modification, system cost, lateral impact, weight, and others factors should be evaluated carefully when considering the use of ANR in the helicopter environment. The communications earplug (CEP) shown in the figure is a device which incorporates a miniature earphone with foam earplug and can be worn in combination with the aviator's helmet. Calculations show the CEP provides adequate hearing protection for 8 hours duty even in the high noise levels found in the H-53. The device also provides voice communication intelligibility which approaches asymptotic limits near 100 percent in those high noise environments. The system is lightweight, cost effective, and does not require modification of the aircraft wiring.

Objective

During the Aircrew Systems Sub-Board (ASSB) meeting of May 1996, NAVAIR, PMA-202 asked for an assessment of the CEP in the Navy H-53 and CH-46 helicopter noise environments. USAARL was tasked to evaluate the effectiveness of the CEP and compare performance of helmets currently used in the H-53A/E and CH-46A/E helicopters using questionnaires and interviews. USAARL provided 20 CEP units with associated connectors, attenuators, and wiring installed in helmets of volunteer crewmen for the performance assessment.

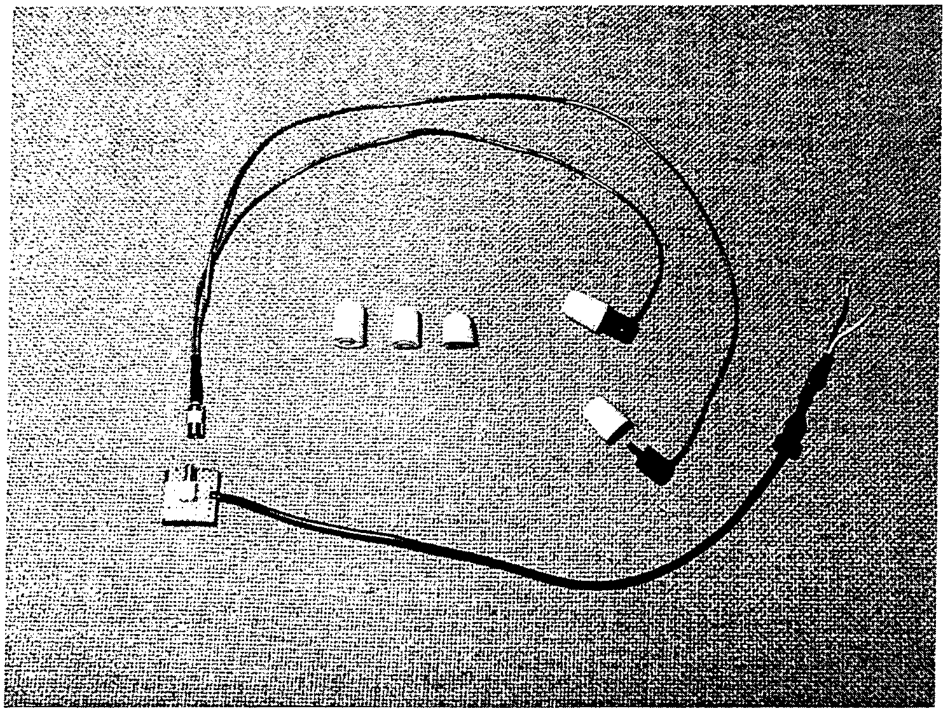

Figure. The communications earplug.

Method

Data collection under this protocol was completed using questionnaires and onsite personal interviews of the volunteers. The responses were used to assess the effectiveness of the CEP when compared to the helmet they currently use. Marine and Navy personnel assigned to the HMX-1 unit at Quantico, Virginia, were briefed on details of the project. A full description of the objectives and issues concerning the CEP and its use in the aviation environment was provided. Female participation in this protocol was encouraged, however, there were no female volunteers present. Twenty volunteers in flight status, 1 Navy and 19 Marines, were accepted for the study. Each individual confirmed their agreement to participate after reading and signing the volunteer informed consent form. Each volunteer then completed a background questionnaire detailing some of their personal experiences in aviation. By the end of the study, five of the volunteers had either transferred from the unit prior to completion or had been assigned to other activities.

Volunteers were instructed on all aspects of the CEP to include proper insertion, replacement and washing of earplug tips, limiting the volume level of the intercommunications system (ICS) at startup, and donning and doffing the helmet. They were instructed on procedures to be used should an unexpected malfunction of the CEP occur. Each volunteer was provided a CEP device for use in the tests along with three pair of replaceable foam tips. Additional tips were available, as needed, during the whole test.

Installation of the CEP into each of the helmets was accomplished by splicing a CEP interface cable assembly into the helmets' existing communication wires. The splice into the

wire was made about 3 inches from the wall of the earcup and insulated with shrink tubing. The other end of the CEP interface cable assembly was terminated with a miniature SMB connector which mates with a connector on the CEP. The connector was held in place on the lower, rear quadrant of the helmet shell surface by an adhesive pad. The interface cable assembly incorporates an electrical attenuator, approximately 20 dB, which is used to reduce the communications signal received from the ICS. The resulting acoustic signal at the ear is comparable to the signal produced by the earcup/earphone system in the helmet.

This study was accomplished over a 3-month period using the CEP/helmet preference questionnaire. The preference questionnaire was utilized to measure the volunteer's assessment of the CEP when compared to the helmet they normally use. The areas of interest were comfort, compatibility, communications performance, utility, and overall value added as assessed by each individual volunteer. In general, the questionnaire used either direct response questions or seven discrete point rating scale questions. Ample opportunity was provided for comments from the volunteer. The rating scale was based on a comparision between the CEP and the helmet normally used by the volunteer with the midpoint (4) indicating no difference between the two. A rating of 7 indicated the user's highest CEP preference value while a 1 indicated the user's highest helmet preference value.

7	6	5	4	3	2	1
Significantly better	Moderately better	Slightly better	Same	Slightly worse	Moderately worse	Significantly worse

The USAARL staff met with the volunteers at the midpoint and end of the study to administer the CEP/helmet preference questionnaire. Results of the questionnaires were analyzed to determine the overall acceptability of the CEP for use in the CH-46 and H-53 missions as assessed by the volunteers. Upon completion of the endpoint questionnaire, the CEP devices were removed from the helmets and turned over to the Navy for disposition.

Results

The summary data showing the background information on the volunteers are in table 1. Fifteen of the volunteers wore the HGU-84 helmet and five listed the CH-46E and CH-53E as the most common aircraft in their experience. The volunteers considered the most demanding or critical times for communications are during multiple incoming transmissions followed by takeoff and night flights. Two of the volunteers experienced tinnitus during or immediately following flights while two experienced muffled hearing after flight. This effect is generally associated with overexposure to noise.

Table 1.
Summary of volunteer's aviation background data.

Average age of the volunteers	31.4 years
Average experience as an aviator/crewmember	8.23 years
Average flight hours	2204 hours
Frequency of difficulty understanding communications	approximately 30%
Frequency of difficulty hearing warning signals	approximately 10%
Volunteers with known hearing loss	5
Volunteers with waiver due to hearing loss	3
Normally wear earplugs with helmet	6 (E-A-R)
Helmet discomfort	5
Volunteers who wear spectacles	8 (6 bayonet, 1 wire temples)
Volunteers disagreeing on ICS volume settings	7
Volunteers who wear skull caps	10

The 15 subjects who completed the 3-month test were used in the midpoint and final assessment of preference between the CEP and their normally used helmet. Both the midpoint and final preference questionnaire results are shown in table 2. For most of the questions, results showed slightly stronger preference between the midpoint to final for the CEP over their standard helmet indicating users found the CEP more acceptable with continued use. The fit and comfort of the CEP was judged to be the same as their standard helmet indicating the perceived potential for discomfort was not realized by the user after 3 months use. There was a difference in favor of the standard helmet in the donning/doffing process because of the extra step required to install the CEP. (It is the authors' opinion that the user will become more proficient in the procedure with continued use of the CEP. Proper planning of the events which take place in the donning process will limit or eliminate problems for even the most time critical mission start.) All of the noise reduction and speech clarity responses indicated a strong preference for the CEP over the standard helmet.

Table 2.
Results of midpoint and final questionnaire assessments (15 subjects).

	Midpoint	Final
Average number of flight-hours using CEP	30.5	40.7
Fit and comfort of CEP	4.2	4.1
Donning/doffing	3.5	3.5
ICS clarity	6.3	6.5
Radio communications clarity	6.3	6.6
Gender clarity (male)	6.1	6.6
Gender clarity (female)	6.0	6.6
Overall clarity	6.3	6.6
Noise reduction	6.3	6.4
Ability to hear warning signals	6.0	6.6
Ability to hear environmental sounds	4.1	4.1
Overall value of CEP	6.1	6.3

Analysis

Table 3 shows that descriptive statistics which include minimum, maximum, mean and standard deviations associated with each of the questions included in the preference questionnaire were completed. An analysis of the responses from the final questionnaire was completed to determine the relationship of the CEP and helmet from the users' subjective assessment. The standard deviations of the fit and comfort, donning/doffing, and environmental sounds question responses may indicate the group consensus is not as well established in these areas as it is in the areas concerning noise reduction and speech clarity/intelligibility. A distribution of the rating of fit and comfort are shown in table 4, along with the responders who did not normally wear earplugs during their flying duties. The four individuals showing fit and comfort ratings below the standard helmet responded as non-earplug users in the background questionnaire. With continued use of the CEP, it is expected that fit and comfort will improve. Donning/doffing is expected to rate lower than the standard helmet in terms of preference, but experience in using the CEP should reduce the effect. The "environmental sounds" variability may be due to a misunderstanding of the question being asked.

Table 3.
Descriptive statistics (final flight evaluation) of the CEP .

Variable	N	Mean	Min	Max	S.D.
Flight-hours	12	40.7	7	100.5	27.12
Fit and comfort	15	4.1	2	7	1.30
Donning/doffing	15	3.5	2	7	1.18
ICS clarity	15	6.5	5	7	.64
Radio clarity	15	6.6	6	7	.51
Gender clarity (male)	15	6.6	5	7	.63
Gender clarity (female)	14	6.6	5	7	.76
Overall clarity	15	6.6	6	7	.51
Noise reduction	15	6.4	4	7	.91
Warning signals	13	6.6	6	7	.51
Environmental sounds	15	4.4	2	7	1.44
Overall value	15	6.3	6	7	.48

Table 4.
Distribution of fit and comfort rating compared with experience using earplugs with helmet.

Rating value	Number of users	Non-earplug user
1	0	
2	1	1
3	3	3
4	8	5
5	0	
6	2	2
7	1	

All of the responses for areas concerning speech clarity or noise reduction indicate the CEP is rated much higher than the current helmet system used by the crewmembers. Ten volunteers rated the overall value at 6 and five rated the overall value at 7. The sound attenuation aspect of the CEP is an important piece of the overall performance of the device. Not only does the sound attenuation of the CEP provide protection from noise hazards found in the military aircraft, it also contributes to the improved speech performance. The simple increase in speech signal-to-noise ratio at the aviator's ear, along with enhanced frequency response and low distortion of the output signal, significantly improves the speech performance.

$$EEL = 10\ Log\left(\sum_{125}^{8000} 10^{\frac{NoiseLevel_i - A\,Weight_i - (\overline{X}_i - 1SD)}{10}}\right)$$

The determination of noise exposure for an individual wearing hearing protection while working in a noise environment is important to assure overexposure to noise hazard does not occur. Perhaps the simplest and most direct approach is to calculate the expected exposure using sound attenuation of the protector and noise levels in the workplace. The Army uses this prediction technique shown in the equation to estimate noise hazard for operational areas where individuals perform their duties. In order to estimate fitting variance across the user population, the laboratory-measured mean attenuation of a hearing protector is reduced by one standard deviation. The exposure is calculated over the range from 125 hertz to 8000 hertz by combining octave band A-weighted noise levels with the measured sound attenuation in that band reduced by one standard deviation. Each of the resultant band levels are summed, using the power value, then converted to dB for the estimated level in dBA.

An estimate of the exposure level in dBA was completed using attenuation data, table 5, collected at USAARL (Ribera et al., 1996; and Mozo and Murphy, 1997) for the HGU-84, HGU-56, HGU-56 with CEP, SPH-4B, and SPH-4B with CEP. Measurements were completed using American National Standards Institute (ANSI) standard S12.6 " Method for the measurement of the real-ear attenuation of hearing protectors" (1984). The noise data are from measurements taken by Navy personnel and provided to USAARL by the Naval Air Warfare Center (NAWC), Warminster, Pennsylvania. The exposure levels were calculated for H-53 and CH-46 noise environments at various locations in the aircraft while the aircraft was performing various flight maneuvers. Results of these calculations in the two aircraft are shown in the appendix.

Table 5.
Real-ear attenuation characteristics of hearing protectors used in estimating effective exposure levels (EEL) in Navy helicopters.

Frequency in Hertz

		125	250	500	1000	2000	3150	4000	6300	8000
HGU-84	Mean	13.8	12.1	19.6	25.3	33.5	40.1	41.7	44.5	45.3
	S.D.	6.9	4.9	3.7	4.1	4.4	5.9	8.3	5.8	4.1
HGU-56	Mean	18.0	19.2	22.7	33.3	31.7	40.4	42.5	43.8	43.4
	S.D.	3.5	3.2	3.5	6.0	4.6	5.0	4.1	6.1	5.8
HGU-56 w/CEP	Mean	29.1	26.0	33.0	30.6	40.1	50.2	55.6	54.1	53.5
	S.D.	6.2	6.6	6.4	3.9	3.9	4.4	6.7	5.7	5.7
SPH-4B	Mean	17.7	15.9	23.3	28.8	26.5	34.2	34.6	41.3	40.6
	S.D.	3.2	2.5	2.7	3.2	3.9	3.3	3.4	3.7	3.8
SPH-4B w/CEP	Mean	28.0	29.1	36.3	29.7	35.9	49.0	51.1	50.8	49.8
	S.D.	12.5	8.6	10.0	5.3	5.4	4.2	3.8	5.6	4.5

A review of the dBA (EEL) values for each of the aircraft and flight conditions show the rank ordering from high to low is HGU-84, SPH-4B, HGU-56, SPH-4B with CEP, and HGU-56 with CEP. Generally the HGU-84 is about 6 dB above the SPH-4B and 7-8 dB above the HGU-56. The combination of helmet worn with the CEP increases that difference to about 10-12 dB.

In accordance with DOD Instruction 6055.12, the time limit for exposure to a noise of 85 dBA is 8 hours within a 24-hour period. The DOD uses an exposure time adjustment which is inversely proportional to level. The rule states that for each 3 dB increase in level, the exposure time must be reduced by one half. Thus, the allowable time in a noise environment which is 6 dB higher is reduced by a factor of four, making a difference of 6 dB very significant in terms of mission duration, crewmember hearing safety, and operational effectiveness. A difference of 12 dB results in a factor of 32 reduction in allowable time in the environment.

Using the CEP in conjunction with the helmet system is very similar, in terms of noise exposure, to wearing the yellow foam earplug with the helmet. However, using the CEP in combination with the helmet provides significant improvements in voice communications when compared to wearing the helmet alone. Based on tests completed at USAARL, the CEP will provide intelligibility levels in excess of 90 percent for phonetically balanced speech material.

Conclusions

Results of this assessment clearly indicate the CEP improves noise reduction and speech intelligibility when compared with the helmet system currently used by the Navy/Marine Corps helicopter crewmembers. Fit and comfort were rated equal to the helmet system currently used. Donning/doffing of the CEP was rated to be slightly less acceptable than the current helmet, but with training and experience this effect should be reduced to be of no consequence. Overall value is a comparison made by the volunteers of all aspects of the CEP relative to the helmet they normally use. The overall value of the CEP was rated at 6.3 using a 7-point scale.

The CEP is a low cost solution to inadequate hearing protection and poor voice communications for high noise environments. Results of this assessment show the CEP system easily integrates into the Navy/Marine Corps helmets and works well in noise environments found in the CH-46 and CH-53 helicopters.

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Appendix

Table 1.
Estimated noise exposure for indicated flight conditions in the CH-46A helicopter at the pilot position while wearing the various hearing protectors.

Flight condition	HGU-84	HGU-56	SPH-4B	HGU-56 with CEP	SPH-4B with CEP
MIL power	86.2	79.1	80.3	74.4	75.6
Normal power	86.2	78.8	80.1	74.2	75.7
T/O power	86.1	81.6	80.9	75.1	76.7

Table 2.
Estimated noise exposure for indicated flight conditions in the CH-46A helicopter at the copilot position while wearing the various hearing protectors.

Flight condition	HGU-84	HGU-56	SPH-4B	HGU-56 with CEP	SPH-4B with CEP
MIL power	85.9	78.7	80.0	74.2	75.2
Normal power	84.4	77.3	78.3	72.2	74.6
T/O power	86.1	78.8	80.1	74.1	75.3

Table 3.
Estimated noise exposure for indicated flight conditions in the CH-46A helicopter at station 160 position while wearing the various hearing protectors.

Flight condition	HGU-84	HGU-56	SPH-4B	HGU-56 with CEP	SPH-4B with CEP
MIL power	90.5	83.2	84.4	78.3	80.1
Normal power	87.9	81.4	83.2	76.3	77.5
T/O power	88.5	81.6	82.5	76.2	77.6

Table 4.
Estimated noise exposure for indicated flight conditions in the CH-46A helicopter at station 254 position while wearing the various hearing protectors.

Flight condition	HGU-84	HGU-56	SPH-4B	HGU-56 with CEP	SPH-4B with CEP
MIL power	90.3	83.2	84.3	77.4	80.0
Normal power	91.7	84.0	85.5	79.2	80.3
T/O power	89.4	82.3	83.1	76.6	79.0

Table 5.
Estimated noise exposure for indicated flight conditions in the CH-46A helicopter at the station 320 position while wearing the various hearing protectors.

Flight condition	HGU-84	HGU-56	SPH-4B	HGU-56 with CEP	SPH-4B with CEP
MIL power	90.5	83.2	84.5	78.1	79.9
Normal power	90.4	83.0	84.7	78.4	78.9
T/O power	90.8	83.6	84.9	78.7	79.6

Table 6.
Estimated noise exposure for indicated flight conditions in the CH-46E helicopter at the pilot position while wearing the various hearing protectors.

Flight condition	HGU-84	HGU-56	SPH-4B	HGU-56 with CEP	SPH-4B with CEP
50' hover doors open	81.3	75.3	75.6	69.4	71.4
Max power 130 knots	84.9	77.9	79.1	73.2	74.0
Normal power 100 knots	81.6	74.9	75.8	69.2	71.6

Table 7.
Estimated noise exposure for indicated flight conditions in the CH-46E helicopter at the copilot position while wearing the various hearing protectors.

Flight condition	HGU-84	HGU-56	SPH-4B	HGU-56 with CEP	SPH-4B with CEP
50' hover doors open	81.1	74.8	75.3	69.0	71.1
Max power 130 knots	84.9	78.9	79.4	73.4	74.2
Normal power 100 knots	81.7	74.7	75.9	69.5	71.3

Table 8.
Estimated noise exposure for indicated flight conditions in the CH-46E helicopter at the hoist operator position while wearing the various hearing protectors.

Flight condition	HGU-84	HGU-56	SPH-4B	HGU-56 with CEP	SPH-4B with CEP
50' hover Doors open	87.5	81.9	82.6	76.1	77.4
Max power 130 knots	86.6	81.6	82.3	76.0	77.5
Normal power 100 knots	85.9	81.1	82.4	75.3	77.1

Table 9.
Estimated noise exposure for indicated flight conditions in the CH-53A helicopter at the pilot position while wearing the various hearing protectors.

Flight condition	HGU-84	HGU-56	SPH-4B	HGU-56 with CEP	SPH-4B with CEP
Hover 50'	78.5	71.7	72.8	66.8	68.1
Max cruise 500'	86.5	80.3	81.2	75.2	76.0
Normal cruise 500'	84.6	78.4	79.1	73.4	74.3
T/O power to 500'	78.2	70.7	72.2	65.7	68.3

Table 10.
Estimated noise exposure for indicated flight conditions in the CH-53A helicopter at the copilot position while wearing the various hearing protectors.

Flight condition	HGU-84	HGU-56	SPH-4B	HGU-56 with CEP	SPH-4B with CEP
Hover 50'	76.1	69.5	70.4	64.2	66.0
Max cruise 500'	86.7	81.0	81.5	75.9	77.3
Normal cruise 500'	85.4	79.4	80.0	74.1	75.6
T/O power to 500'	79.3	72.5	73.6	66.6	69.8

Table 11.
Estimated noise exposure for indicated flight conditions in the CH-53A helicopter at the crew chief position while wearing the various hearing protectors.

Flight condition	HGU-84	HGU-56	SPH-4B	HGU-56 with CEP	SPH-4B with CEP
Hover 50'	81.3	73.7	75.5	69.4	70.1
Maximum cruise 500'	87.2	80.5	81.7	75.7	76.7
Normal cruise 500'	84.6	78.4	79.3	73.4	74.3
T/O power to 500'	80.6	73.6	75.7	69.0	70.3

Table 12.
Estimated noise exposure for indicated flight conditions in the CH-53A helicopter at the station 282 position while wearing the various hearing protectors.

Flight condition	HGU-84	HGU-56	SPH-4B	HGU-56 with CEP	SPH-4B with CEP
Hover 50'	79.4	73.0	75.0	67.9	69.6
Maximum cruise 500'	85.3	79.0	80.1	73.8	74.6
Normal cruise 500'	84.1	77.3	78.8	72.3	73.5
T/O power to 500'	83.0	76.3	78.3	71.1	72.6

Table 13.
Estimated noise exposure for indicated flight conditions in the CH-53A helicopter at the station 462 position while wearing the various hearing protectors.

Flight condition	HGU-84	HGU-56	SPH-4B	HGU-56 with CEP	SPH-4B with CEP
Hover 50'	81.2	75.3	76.8	69.8	71.7
Maximum cruise 500'	88.7	81.7	83.3	76.9	77.9
NMRM cruise 500'	84.4	78.1	79.1	72.9	74.7
T/O power to 500'	85.1	78.4	80.1	73.4	74.7

Table 14.
Estimated noise exposure for indicated flight conditions in the CH-53E helicopter at the AFT cabin position while wearing the various hearing protectors.

Flight condition	HGU-84	HGU-56	SPH-4B	HGU-56 with CEP	SPH-4B with CEP
Cruise 1500' 100%	93.4	86.8	87.6	81.7	82.6
Cruise 1500' 105%	96.4	89.5	90.4	84.5	85.6
Cruise 3000' 100%	93.3	86.5	87.4	81.4	82.5
Cruise 3000' 105%	97.1	89.6	90.9	84.7	86.2
Ground idle 100%	90.2	82.7	84.1	78.0	79.6
Ground idle 105%	92.3	84.8	86.2	79.9	81.8
Hover 150' - 100%	90.9	84.9	85.5	79.9	80.8
Hover 150' - 105%	91.9	85.6	86.4	80.5	81.7
Hover 50' - 100%	91.0	84.2	85.3	79.5	80.2
Hover 50' - 105%	91.2	85.2	85.8	80.0	81.3
Maximum control power	96.8	90.1	90.9	84.9	86.3

Table 15.
Estimated noise exposure for indicated flight conditions in the CH-53E helicopter at the forward cabin position while wearing the various hearing protectors.

Flight condition	HGU-84	HGU-56	SPH-4B	HGU-56 with CEP	SPH-4B with CEP
Cruise 1500' 100%	89.5	84.0	84.7	78.8	79.5
Cruise 1500' 105%	86.4	79.2	81.0	75.1	75.8
Cruise 3000' 100%	84.3	78.6	79.0	73.1	74.0
Cruise 3000' 105%	89.6	84.7	84.4	78.5	79.2
Ground idle 100%	86.8	79.8	81.1	75.1	75.8
Ground idle 105%	86.3	81.1	81.1	75.0	76.4
Hover 150' - 100%	87.1	83.1	82.4	76.6	77.4
Hover 150' - 105%	91.5	87.9	86.9	81.2	82.0
Hover 50' - 100%	87.2	83.2	82.6	77.0	77.9
Hover 50' - 105%	90.8	87.0	86.0	80.5	81.4
Maximum control power 100%	90.9	86.4	86.0	80.2	81.0
Maximum control power 105%	92.4	88.2	87.5	81.7	82.5

Table 16.
Estimated noise exposure for indicated flight conditions in the CH-53E helicopter at the middle cabin position while wearing the various hearing protectors.

Flight condition	HGU-84	HGU-56	SPH-4B	HGU-56 with CEP	SPH-4B with CEP
Cruise 1500' 100%	89.7	83.9	84.4	78.4	79.8
Cruise 1500' 105%	92.0	85.0	86.3	81.2	82.2
Cruise 3000' 100%	86.1	80.3	82.1	75.1	77.1
Cruise 3000' 105%	91.0	84.3	85.4	79.5	80.2
Ground idle 100%	86.1	80.3	81.2	75.2	76.4
Ground idle 105%	87.7	83.1	86.1	76.7	79.4
Hover 150' - 100%	90.3	86.3	85.8	80.2	81.2
Hover 150' - 105%	91.4	87.2	86.7	81.1	81.9
Hover 50' - 100%	88.8	84.2	84.5	79.2	80.6
Hover 50' - 105%	91.3	86.7	86.8	80.7	81.6
Maximum control power 100%	94.0	88.4	88.7	82.9	83.4

Table 17.

Estimated noise exposure for indicated flight conditions in the CH-53E helicopter at the pilot/copilot position while wearing the various hearing protectors.

Flight condition	HGU-84	HGU-56	SPH-4B	HGU-56 with CEP	SPH-4B with CEP
Cruise 1500' 100%	86.4	78.8	80.5	74.5	75.1
Cruise 1500' 105%	data not available				
Cruise 3000' 100%	83.3	76.3	77.1	70.7	73.8
Cruise 3000' 105%	85.4	79.0	79.5	73.3	75.7
Ground idle 100%	82.4	75.3	76.4	70.3	71.8
Ground idle 105%	84.0	77.2	78.0	71.8	73.4
Hover 150' - 100%	81.1	75.4	75.8	69.9	70.5
Hover 150' - 105%	81.5	75.8	76.3	70.6	71.7
Hover 50' - 100%	82.8	76.1	77.2	71.4	71.8
Hover 50' - 105%	82.9	77.9	77.8	72.1	73.2
Maximum control power 100%	89.6	82.6	83.8	77.9	78.4
Maximum control power 105%	88.6	81.3	82.7	76.8	77.4